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Materiel Test Procedure 6-2-250
Electronic Proving GroundU. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

RELAYS, RADIO

1. OBJECTIVE

The objective of this materiel test procedure is to describe engineering test procedures required to determine the technical performance and characteristics of radio assemblages employed as the intermediate stations in radio relay communication systems, relative to the criteria given in applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), and other applicable requirements or documentation, and determining their suitability for an intended use.

2. BACKGROUND

The term "radio relay system" as used herein applies to integrated, trunk-line type radio systems characterized by:

- a. An overall, terminal-to-terminal path made up of a variable number of line-of-sight radio-frequency links connected in tandem at relay stations.
- b. Radio sets of same type used at both terminal and relay stations.
- c. Directional antenna systems.
- d. Duplex operation, i. e. simultaneous two-way transmission.
- e. Capability of multichannel operation by application of compatible multiplexing systems.
- f. Rapid deployment capability.

Tactical radio relay systems of various types utilize the VHF, UHF, and SHF bands of the radio frequency spectrum and are sometimes loosely referred to as "microwave" systems. Two system characteristics of tactical importance are (1) the inherent directivity of each link which allows extensive duplication of RF channel assignments and (2) the segmental characteristic which permits flexibility in overall route selection with respect to terrain.

The radio relay set of a given system may consist essentially of two radio sets, identical to the terminal radio set, connected "back-to-back", i.e. at the modulator-demodulator (baseband) point and combined into one mobile or transportable assemblage. Each "radio set" includes the integral antenna system. To provide operational flexibility, the relay assemblage may be designed for alternate employment as a dual terminal with integral or external multiplex sets for two separate system.

Engineering tests of radio relay sets operating in a representative system are required to determine the extent to which the test item meets the technical performance requirements and to determine the suitability for service test.

3. REQUIRED EQUIPMENT

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- a. Electronic testing laboratory equipped for precision radio frequency measurements.
- b. Test areas suitable for establishment of radio links applicable to the test item.
 - c. Signal/function generators.
 - d. Noise generator.
 - e. Frequency meter/electronic counter.
 - f. Wave analyzer.
 - g. RF noise and field intensity measuring set.
 - h. Noise measuring set.
 - i. Transmission measuring set.
 - j. Distortion analyzer.
 - k. Voltmeter, AC with db scale.
 - l. Multimeter.
 - m. Oscilloscope, dual, w/camera.
 - n. Special test set(s), designed for use with but not integral to the test item.
- o. Power equipment (when not part of the test item).
- p. Instrumentation vehicles.
- q. Patch panel assemblies and interconnecting wire and cables.
- r. End instruments or instrumentation simulating telephones, teletypewriters, facsimile, data equipment, video equipment and switching systems.
 - s. Converters (e.g. 2-wire/4-wire, signaling, data, etc.).
 - t. Meteorological support facility.
 - u. Test data acquisition equipment/system.

4. REFERENCES

- A. MIL-STD-188(), Military Communication System Technical Standards
- B. MIL-STD-449(), Radio Frequency Spectrum Characteristics, Measurement of
- C. MIL-STD-463(), Electromagnetic Interference Technology, Definitions and System of Units
- D. TM 11-486, (series), Electrical Communication Systems Engineering
- E. Applicable Technical Manuals on tactical radio relay equipments and systems
- F. Applicable Qualitative Materiel Requirements (QMR) and Technical Characteristics (TC)
- G. MTP 3-1-002, Confidence Intervals and Sample Size
- H. MTP 6-2-020, Radar Subsystem Antenna Tests
- I. MTP 6-2-242, Receiver-Transmitter, General
- J. MTP 6-2-288, Terminals, Radio
- K. MTP 6-2-507, Safety
- L. MTP 6-2-514, Electrical Power Requirements

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

The procedures outlined in this MTP provide general guidance for evaluating the technical performance and characteristics of the relay/repeater sets of radio relay communication systems relative to the requirements expressed in pertinent QMR, SDR, TC, or other applicable documents. The cumulative test results, along with the results of appropriate common engineering tests, will allow an estimate to be made of the ability of relay/repeater equipment to provide communications over selected paths.

The specific tests to be performed are divided into component laboratory and system field tests. These tests, and their intended objectives, are as follows:

a. Component Tests

- 1) Electromagnetic Characteristics - The objective of this sub-test is to determine if the transmitter and receiver characteristics as well as the antenna field pattern and directional characteristics of the item under test meet applicable criteria.
- 2) Primary Power Tests - The objective of this sub-test is to determine if the primary power requirements of the item under test meets applicable criteria.

b. System Tests

- 1) System Tests - The objective of this sub-test is to determine the test item system performance in terms of degree of correct information transfer versus transmission paths of variable number and characteristics, and the degradation of information transfer caused by intra-system interference.
- 2) System Quality and Compatibility Tests - The objective of this sub-test is to determine if the communication quality and compatibility with end instruments characteristics of the item under test meets applicable criteria.

5.1.2 Common Engineering Tests

The following Common Engineering Tests, applicable to these commodities, are not included in this MTP:

- a. 6-2-500, Physical Characteristics.
- b. 6-2-502, Human Factors Engineering.
- c. 6-2-504, Design for Maintainability.
- d. 6-2-508, Electromagnetic Vulnerability.
- e. 6-2-509, Electromagnetic Compatibility.
- f. 6-2-516, Adequacy of Shelter and Van Mounted Lighting, Ventilation, Air Conditioning and Heating Equipment.
- g. 6-2-520, Transportability of Communication, Surveillance and Electronic Equipment.

- h. 6-2-530, Altitude and Temperature Altitude Test.
- i. 6-2-531, Temperature Test.
- j. 6-2-532, Sunshine Test.
- k. 6-2-533, Rain Test.
- l. 6-2-534, Humidity Test.
- m. 6-2-535, Fungus Test.
- n. 6-2-536, Salt Fog Test.
- o. 6-2-537, Dust Test.
- p. 6-2-538, Explosive Atmosphere Test.
- q. 6-2-539, Immersion Test.
- r. 6-2-540, Vibration Test.
- s. 6-2-541, Shock Test.

5.2 LIMITATIONS

Interface equipment (or special components) which may be required at relay stations for certain types of multiplex system, e.g. PCM-TDM, is not considered part of the test item for the purpose of this MTP. When so directed as an engineering test of a specific combination of equipment, the appropriate MTP's shall be followed.

Although technically a "radio relay", the junction of two normally single-hop systems connected in tandem to span a greater distance does not constitute a radio relay/repeater set in the context of this test procedure.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Select test equipment ideally having an accuracy of at least ten orders of magnitude greater than that afforded by the item under test that is in keeping with the state of the art, and with calibrations traceable to the National Bureau of Standards.

b. Record the following information:

- 1) Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
- 2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Ensure that all test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).

d. Review all instructional material issued with the test item by the manufacturer, contractor, or government. These documents shall be kept readily available for reference.

e. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.

f. Prepare adequate safety precaution to provide safety for personnel

and equipment, and ensure that all safety SOP's are observed throughout the test and that the item has successfully completed MTP 6-2-507, Safety.

g. Thoroughly inspect the test item for obvious physical and electrical defects such as cracked or broken insulation, loose connections, bare or broken wires, loose assemblies, bent fragile parts, and corroded plugs and jacks. All defects shall be noted and corrected before proceeding.

h. Prior to beginning any sub-test, verify correct power source, necessary test instrumentation and inter-connecting cabling, and that the equipment is aligned, if necessary, as specified in the pertinent operating instructions to ensure, insofar as possible, it represents an average equipment in normal operating condition.

i. Prepare a test item sample plan sufficient to ensure that enough samples of all measurements are taken to provide statistical confidence of final data in accordance with MTP 3-1-002. Provisions shall be made for modification of the plan during test progress as may be indicated by monitored test results.

j. Ensure that arrangements for supporting and participating agencies, activities and facilities have been made, that authorization for electromagnetic radiation at specific frequencies, power levels and modulations for required periods has been obtained, that all personnel have been briefed on the purposes of the tests and the results expected, and that appropriate security measures are instituted, as required, to safeguard classified materiel and data.

6.2 TEST CONDUCT

NOTE: Modification of these procedures shall be made as required by technical design of the item under test and availability of test equipment, but only to the extent that such modified procedures will not affect the validity of the test results.

6.2.1 Component Tests (Laboratory)

6.2.1.1 Electromagnetic Characteristics

a. Determine the electromagnetic characteristics of the item under test in accordance with the procedures given in MTP 6-2-020, Radar Subsystem Antenna Tests and MTP 6-2-242, Receiver-Transmitter, General. Each radio set of each test item shall be tested as described for the matching terminal radio set in MTP 6-2-288, Terminals, Radio.

NOTE: Principal parameters to be measured in accordance with the above procedures shall include but not be limited to:

1) Antenna

- a) Radiation pattern measurements
- b) Gain
- c) Polarization
- d) Phase front determination

2) Transmitter

- a) Power output
- b) Frequency accuracy and stability
- c) Spurious emissions
- d) Carrier noise level
- e) Sidetone response
- f) Modulator bandwidth
- g) Modulation characteristics

3) Receiver

- a) Frequency range
- b) Sensitivity
- c) Selectivity
- d) Audio frequency response
- e) Spurious response
- f) Dynamic range

b. Record data in accordance with the above procedures.

6.2.1.2. Primary Power Tests

- a. Subject the item under test to the procedures given in MTP 6-2-514, Electrical Power Requirements.
- b. Record data in accordance with the above procedure.

6.2.2 System Tests (Field)

6.2.2.1 System Tests

- a. Lay out selected terminal-to-terminal paths representative of typical tactical radio-frequency links (See Figure 1.) on a topographical map. The map shall show test sites, distances, and angular relationship of links.
- b. Install a minimum of two test items in conjunction with the appropriate type of multichannel terminal sets, at typical tactical test sites.

- NOTE:
- 1. The maximum number of test system links (test items + 1) to be installed is dependent upon the type of test item.
 - 2. The test item configuration shall provide line-of-sight (LOS) transmission paths of different characteristics ranging from average to near-average conditions with respect to:
 - a. Link length (LOS distance).
 - b. Clearance of LOS above inter-station terrain (Fresnel-zone clearance).
 - c. Angular relationship of contiguous links.
 - 3. Variation of the above factors shall be in consonance with the test item characteristics, for example; frequency band

(VHF, UHF, or SHF), antenna pattern, antenna height and diversity capability. General guidance in planning the test system may be obtained from the radio relay section of TM 11-486-6.

c. Coordinate with the Meteorological Support Facility to ensure that meteorological information is obtained during all periods of operation.

- NOTE: 1. Frequency at which meteorological observations are to be repeated shall be as mutually agreed upon by the test engineer and the support activity.
2. The upper-air data provided shall include the height and intensity of all inversions and the refractive index or gradient of the index when conditions deviate from the standard radio atmospheric conditions.

d. Install calibrated instrumentation as required to measure frequencies, RF noise data, levels, bandwidths, modulation characteristics, and signal directions.

e. Establish an RF carrier link in accordance with the test item applications manual and operate continuously for a minimum period of five days over the selected radio path. The operating frequency shall be selected in accordance with frequency assignment/mutual interference charts or instructions furnished with or applicable to the test item (reference TM-11-486-6).

NOTE: Operating frequencies shall be changed at appropriate intervals (see MTP 3-1-002) during the test period to provide combinations presenting optimum and marginal interference conditions throughout the test item frequency range.

f. Record the following information:

- 1) Topographical map or scaled diagram of each test system layout showing test sites, distances, and angular relationship of links.
- 2) Profile diagram of each link.
- 3) Diagrams and/or photographs of each relay site depicting principally the antenna correlation.
- 4) Frequency assignments by link and test phase.
- 5) Records of meteorological conditions by location for entire test period.
- 6) Ambient RF noise data to include frequency bands, levels, location, and correlating information.

NOTE: 1. Ambient noise shall be measured by use of a noise and field intensity meter.
2. Wide band measurements shall be made in terms of decibels above 1 microvolt per megahertz at logarithmic intervals across the frequency range of interest. If an RF carrier is noted, the measuring

instrument shall be detuned until a clear frequency is found.

3. Measurements shall be made at sufficient time intervals throughout the test period (see MTP 3-1-002) to adequately describe the ambient noise conditions.

- 7) RF signal strength data to include both desired and undesired signals identified by frequency, source and test conditions.
- 8) Channel measurement and traffic test data.

NOTE: This data shall be recorded as described in MTP 6-2-288. Data obtained from the closed-system tests of the system radio terminals as covered in MTP 6-2-288 shall be included for comparative analysis.

- 9) Baseband measurement data (recorded in a manner appropriate to the selected method).

g. Repeat Steps (e) and (f) above, for each equipment physical configuration. Frequent and periodic checks shall be made on channels and order wire to ensure operability between test runs.

6.2.2.2 System Quality and Compatibility Tests

a. During the conduct of Steps (e), (f) and (g) of paragraph 6.2.2.1 above, perform the operational test portion of the specified commodity engineering test procedure on the end instruments as connected to the relay/repeater sets of the radio relay communication system under test in an RF link configuration.

b. Record data as specified in Step (f) of paragraph 6.2.2.1 in addition to the data required by the operational test portions of the applicable commodity engineering test procedure.

NOTE: Measurements appropriate to the test item and system multiplexing shall be made on a monitoring basis at the baseband interconnection point at each relay site during idle periods as well as during the above tests.

c. Compare the individual end instrument commodity test results achieved with the end instrument operating in conjunction with the radio relay system.

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include but not be limited to:

a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.

b. Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Damages to the test item incurred during transit and/or manufacturing.

6.3.2 Test Conduct

Data to be recorded in addition to specific instructions listed below for each sub-test shall include:

a. A block diagram of the test setup employed in each specified test. The block diagram shall identify by model and serial number, all test equipment and interconnections (cable lengths, connectors, attenuators, etc.) and indicate control and dial settings where necessary.

b. Photographs or motion pictures (black and white or color), sketches, charts, graphs, or other pictorial or graphic presentation which will support test results or conclusions.

c. An engineering logbook containing, in chronological order, pertinent remarks and observations which would aid in a subsequent analysis of the test data. This information may consist of temperatures, humidity, pressures, and other appropriate environmental data, or other description of equipment or components, and functions and deficiencies, as well as theoretical estimations, mathematical calculations, test conditions, intermittent or catastrophic failures, test parameters, etc., that were obtained during the test.

d. Test item sample size (number of measurement repetitions).

e. Instrumentation or measurement system mean error stated accuracy.

6.3.2.1 Component Tests (Laboratory)

6.3.2.1.1 Electromagnetic Characteristics

Data obtained from electromagnetic characteristics sub-tests shall be recorded in accordance with applicable portions of MTP's 6-2-020 and 6-2-242, and shall consist of measurements of the following parameters:

a. Antenna

- 1) Radiation pattern measurements
- 2) Gain
- 3) Polarization
- 4) Phase front determination

b. Transmitter

- 1) Power output
- 2) Frequency accuracy and stability
- 3) Spurious emissions
- 4) Carrier noise level
- 5) Sidetone response
- 6) Modulation bandwidth

7) Modulation characteristics

C. Receiver

- 1) Frequency range
- 2) Sensitivity
- 3) Selectivity
- 4) Audio frequency response
- 5) Spurious response
- 6) Dynamic range

6.3.2.1.2 Primary Power Tests

Data obtained from primary power sub-tests shall be recorded in accordance with applicable portions of MTP 6-2-514.

6.3.2.2 System Tests (Field)

6.3.2.2.1 System Tests

Data to be recorded for each equipment physical configuration of system tests shall consist of the following:

- a. Topographical map or scaled diagram of each test system layout.
- b. Profile diagram of each link.
- c. Diagrams and/or photographs of each relay site.
- d. Frequency assignments.
- e. Records of meteorological conditions.
- f. Ambient RF noise data.
- g. RF signal strength data.
- h. Channel measurement and traffic test data.
- i. Baseband measurement data.

6.3.2.2.2 System Quality and Compatibility Tests

Data to be recorded for system quality and compatibility tests shall consist of the data required by the operational test portions of the applicable commodity engineering test procedures for the end instruments under test in addition to the data delineated in paragraph 6.3.2.2.1, above.

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data shall, in general, consist of organizing, marking for correlation and identification, and grouping the test data according to sub-test title. Test criterion or test item specifications shall be noted on the test data to facilitate analysis and comparison. Where necessary, test data measurements shall be converted to be compatible with units given by test criteria or specifications.

Specific instructions for the reduction and presentation of individual sub-test data are outlined in the succeeding paragraphs.

6.4.1 Component Tests (Laboratory)

6.4.1.1 Electromagnetic Characteristics

Electromagnetic Characteristics test data shall be reduced and presented in accordance with MTP's 6-2-020 and 6-2-242.

6.4.1.2 Primary Power Tests

Primary power test data shall be reduced and presented in accordance with MTP 6-2-514.

6.4.2 System Tests (Field)

6.4.2.1 System Tests

Data resulting from the selected tests shall be reduced and correlated by the most expeditious means and presented as described in the applicable sections of the referenced documents.

Composite test results shall be presented by methods and in a manner clearly describing test item system performance in terms of degree of correct information transfer versus transmission paths of variable number and characteristics.

6.4.2.2 System Quality and Compatibility Tests

System quality and compatibility with end instrument test data shall be reduced and presented in accordance with paragraph 6.4.2.1 above, and in accordance with the operational test portion of the applicable commodity engineering test procedure.

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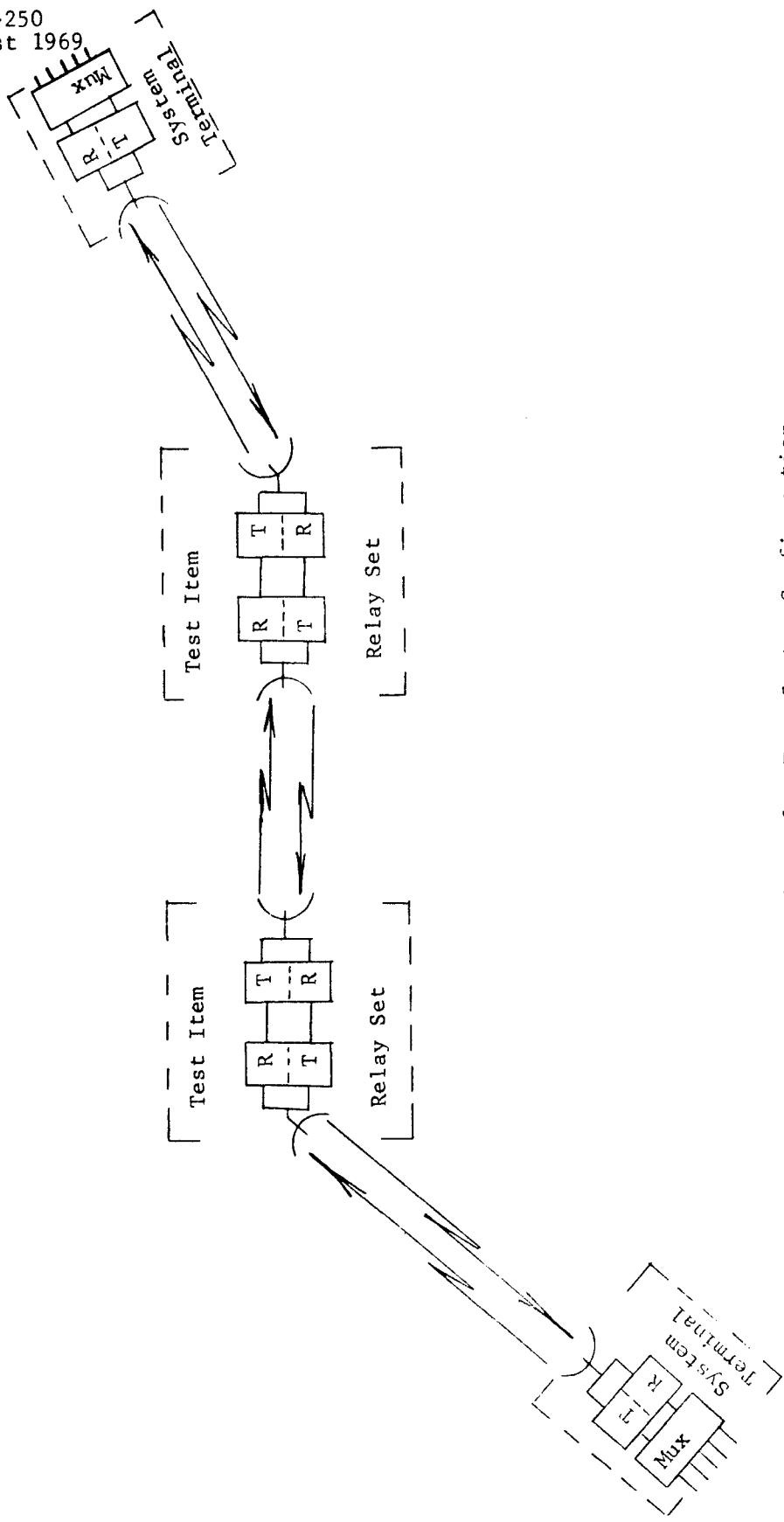


Figure 1. Basic Radio Relay Test System Configuration.